VOL. XLII NUMBER 2 WHOLE NUMBER 371

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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PUBLISHED BI-MONTHLY
(*Six numbers per year*)

March-April, 1948

PRINTED FOR THE SOCIETY
TORONTO: 3 WILLCOCKS ST.

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Address of Editors: David Dunlap Observatory, Richmond Hill, Ont.

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$2.00 per annum, Single number, 25 cents.

Subscription to the JOURNAL is included in membership fee.

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Society Headquarters—3 Willcocks St.

PRINTED IN CANADA

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THE PROBLEM OF SPACE TRAVEL*

By J. W. CAMPBELL

INTRODUCTION

THE past fifty years has been a period of stupendous developments in the field of science. Fifty years ago scientists had a sense of the great achievements that had been realized, and they had a great confidence in the fundamental groundwork that had been laid. In speaking of Sir Isaac Newton the French mathematician Lagrange described him as the greatest genius that ever existed, and also as the most fortunate, "for we cannot find more than once a system of the world to establish." No one will question the genius of Newton, but the development of the theory of relativity has doubtless altered our view regarding the latter part of Lagrange's statement.

The developments in physics and astronomy have been enormous, when comparison is made with what was known at the turning of the twentieth century. But these have been only typical of developments in other realms, and not the least of these developments has been that in the modes of travel. It was just about a century ago that the first railroads were built, and the decades which followed saw great progress because of the advance from horse drawn vehicles and sailing vessels. Then followed in the early years of this century the automobile and the airplane, and what progress has been made! One recalls how wonderful it

*Address of the President at the Annual At-Home of the Royal Astronomical Society of Canada, Toronto, January 23, 1948.

was regarded when the Atlantic was first flown by Sir John Alcock just after the First Great War. That flight was made from west to east, and one also recalls the time that elapsed and the number of planes that were lost before the flight was made from east to west. But now there is regular scheduled airservice over all the trade routes of the world.

This is truly an age of travel. The past fifty years have seen a steady improvement in the old modes of travel and we now have luxurious streamlined trains. The steady improvement in automobiles and in the system of state highways has made extended travel for the masses possible on a vast scale. Then the remarkable developments in air travel have revolutionized possibilities. There are many examples that one might cite in this regard, but there is perhaps no more graphic one than the experience of Admiral Byrd in his latest Antarctic Expedition as told by him in a recent number of the National Geographic.

And the end is not yet. There are many who feel that travel experiences have just begun. They want to go higher and farther, to leave the earth and visit the moon, even to visit Mars and Venus, and societies have been formed to make plans towards these ends. In Britain there is the British Interplanetary Society, in America there is the American Rocket Society, and in several other countries there are corresponding organizations. One sees not infrequently in the press, plans or claims of possibilities, for making such trips.

Some Opinions on Space Travel

In March 1947, there appeared the following Reuters dispatch from London:

A trip to the moon "within the next 50 or 60 years" in a spaceship travelling at thousands of miles an hour was visualized by Prof. A. M. Low in an interview Monday.

The past president of the British Inter-Planetary society pictured pioneers wearing suits designed for protection against intense heat and cold and carrying their own oxygen supplies, seated in a giant space-ship navigated by radar and driven by atomic energy.

Hundreds of thousands of people will almost certainly be killed in first attempts at inter-planetary travel, but if as much money were to be spent on designing space-ships as has been spent on designing weapons of war a safe method of making the journey would no doubt be found in time,' he said.

Concerning these plans and possibilities there is a variety of opinions expressed. Professional astronomers in general discount the possibilities.

Just over a year ago the British Astronomer Royal, Sir Harold Spencer Jones, was reported to have expressed himself somewhat in this manner:

> Man quite likely will never reach the moon and even if he did, the chances of his returning would be so small as to be negligible. For assuming that the difficulties of launching a lunar liner could be overcome, the landing on a jagged surface such as the moon would almost certainly involve disaster, and if the landing were successful there would be no launching platform for the return trip.

Earlier (1935) the following statement concerning interplanetary travel was made by Dr. F. R. Moulton in his book *Consider the Heavens*:

> It must be stated that there is not the slightest possibility of such a journey. There is not in sight any source of energy that would be a fair start toward that which would be necessary to get us beyond the gravitative control of the earth. There is no theory that would guide us through interplanetary space to another world even if we could control our departure from the earth; there is no means of carrying the large amount of oxygen, water and food that would be necessary for such a long journey; and there is no known way of easing our ether ship down on the surface of another world, if we could get there.

On the other hand there are optimistic statements attributed to some other trained scientists.

An article entitled *Stargazing for Fun*, which appeared in the *Pic* magazine for July, 1947, contained the following paragraph:

> Continuing government-sponsored rocket experiments mean, believe it or not, that contact with another planet may be established in this generation, and interplanetary travel itself may become a reality within this lifetime. Dr. Samuel Herrick, Assistant Professor of Astronomy at U.C.L.A., and 10 members of his class on interplanetary travel already are hard at work on 'calculations which may become the charts for man's first interplanetary expeditions.' These charts will describe calculated curves actually amounting to orbits like those in which all celestial bodies seem to travel. It's quite possible, according to Dr. Herrick, that the first one or two space ships will miss their mark, become eternal travellers in space, an eventuality that must be taken into consideration as work goes forward plotting a trip to Venus, a mere 25,000,000 miles away.

These are samples of opinions, and in view of their divergent character I have thought that a consideration of some of the problems involved might be of interest.

The Character of Space Travel

Consider first some familiar means of travel, and how they are effected.

When an ocean liner sails the seas the turbine screws are turned by the engines, there is a backward push on the water by the screws and there is a forward push on the screws by the water—Newton's third law. Thus the engines by their power induce the water to drive the ship forward.

A motor car, truck or locomotive is propelled similarly. In each case the motor turns the drive wheels. The wheels push back on the roadway or rails if there is traction, and the roadway or rails push forward on the car or locomotive. This forward force that is induced propels the car or locomotive.

Thirdly, an airplane by its motors spins the propellers. The propellers press back on the atmosphere and this induces the air to push forward on the airplane. The result is propulsion of the airplane.

But in order to propel a space ship another method is necessary. When a shell is fired from a gun the shell receives a high forward velocity, the principle being that the momentum imparted to the shell by the combustion of the charge is equal and opposite to the momentum imparted to the gun. By shock absorbing devices the velocity of the gun is damped out in terrestrial firing, but if a gun were fired in space where there was no damping mechanism the gun would not be stopped. However, the velocity imparted to the shell would not depend on whether the gun stopped or not.

This is the so-called principle of rocket propulsion. If the fired shell were such that it in turn could be fired like a gun, an inner shell could be projected if the rest of the first shell were used as the gun. Then using the second shell, a third inner shell could be projected forward with the remainder of the second shell used as the gun.

Proceeding in this way the velocity of the innermost shell could be built up. But it should be noted clearly what is involved. At each firing, in order to give larger speed to the shell it is necessary that the gun be of larger mass. To get a 10 to 1 ratio of velocities it would be necessary to have a 1 to 10 ratio of masses. Or, to put

it more simply, if the shell fired were 1/10 of the total mass from which it was fired at each stage, then the second shell would be 1/100 of the original mass, the third shell would be 1/1000 of the original mass, and so on. That is, the shell at successive firings would decrease according to the exponential law. Or, looking in the other direction, if it was desired to have a shell of a given size after the last firing, then if this were the nth firing it would be necessary to start with a mass 10^n times as massive. That is, the initial mass needed would increase according to the exponential law in terms of the number of firings that were to be made.

Earlier this year there appeared a newspaper article with the caption "Postage Rate to Moon Around $20,000,000 Now." The article was based on a despatch from Washington, and it said that a group of army ordnance officers, who hadn't the slightest intention of trying it, had made a lot of calculations on what might be done with present equipment to shoot a projectile to the moon.

First, it would be necessary to attain a speed of 36,000 feet—about 7 miles—a second. The present V-2 rockets, weighing about 15 tons, attain speeds of a little better than a mile a second. The V-2 can carry in its war-head a payload of about 1 ton. This load could be a smaller rocket of about the same design. It would be sent out automatically as soon as the V-2 attained its top speed, about 125 miles above the earth. With its own initial velocity added to the speed of the V-2 launching it, the rocket then would be moving at about 12,000 feet a second, at an altitude of 250 miles. At this point a third rocket weighing about 35 pounds would be released, with a speed of its own about 6,000 feet a second. This, added to the speed of rocket number two at a height of about 400 miles, would send number three shooting off at nearly 20,000 feet a second. Number three could carry a fourth rocket weighing about 7 pounds, whose speed of some 7,000 feet a second added to the earlier velocity, would propel it, 500 miles up, at a speed close to 28,000 feet a second—still more than a mile a second slower than is necessary to escape the earth's gravitational field.

Seven pounds, the ordnance officers say, is about the lightest weight possible for a successful rocket. At least one and probably two more steps would be necessary. The only way to attain these, they say, would be to build a primary rocket on the pattern of the V-2 but weighing about 100 tons. Then each succeeding rocket would be made larger—until it would be possible to hit the moon, if the projectile happened to go in that direction, with a lump of iron about the size of a man's fist. But, they point out, once in free space there would be no possible way of controlling the flight of the projectile. The moon would be a very small target in the whole space, and the probability that the ast rocket would find it is almost infinitesimal.

Now this is a rather crude picture of the problem but it gives something of a skeleton idea of what is involved, and it features some cardinal principles to which I should like to direct attention. Before enumerating these, however, I should like to call attention to the manner of operation of the V-2 rocket, for it operates on the mass-propulsion principle.

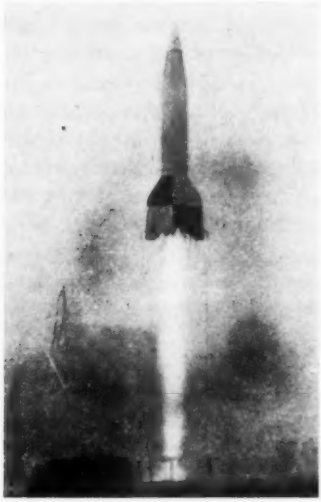


FIG. 1

Figure 1 indicates the nature of the V-2 rocket and its manner of propulsion. The rocket is streamlined, and instead of discarding guns, as described in the first picture of how space propulsion is possible, a steady jet of fuel is ejected. The fuel, liquid oxygen, is combusted and the gases blown back at high speed. The principle is the same—there is a gain in forward momentum of the rocket equal in amount to the backward momentum of the ejected gases.

Also, it should be noted that the departure of each interior rocket from the preceding one is not suggested as being by the

firing, or ejection, principle. Rather, the outer shell is released so as to allow the inner rocket to be propelled more effectively by the ejection of its liquid fuel.

With these principles of operation in mind there are four cardinal facts of space travel illustrated, and they cannot be realized too clearly.

(1) Having started out on a space trip in any manner there is a limit beyond which you cannot go in effecting propulsion by ejecting matter. When this minimum mass has been reached there is no further "control" possible.

(2) There are no filling stations in space and if the minimum mass were reached there would be no means of remedying the situation.

(3) The way to avoid reaching the helpless state of the minimum mass condition is to start out with ample material at the beginning.

(4) The only way to have ten-fold the limiting mass at your disposal after a given time is to start out with ten-fold the initial mass—not to take along an extra ten-fold of the limiting mass.

The statement that there is no means of controlling the flight of a projectile after it leaves the earth's atmosphere needs qualification. The ordnance officers were evidently referring to pilotless projectiles. But we shall consider pilotted rockets, and this will serve to make clear the principles involved.

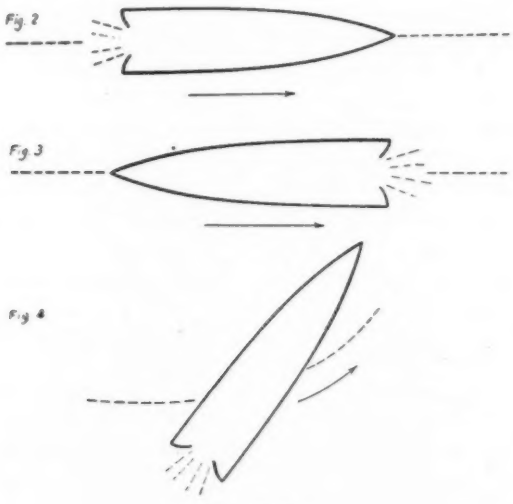
The V-2 Rocket Type of Ship

In February, 1947, a book entitled *Rockets and Space Travel* was published by Willy Ley.* The author has long been a protagonist of space travel and this book may probably be taken as representative of the present day ideas of those who ardently believe in the possibility of travel outside our atmosphere. I shall use the type of space ship which he describes as a basis for discussing the problem of manoeuvring in outer space.

The ship envisaged by Ley is built on the principle of the V-2 rocket. An important feature of the construction is that the ship

*Viking Press.

is streamlined and that the ejection of the combusted fuel is all in one direction with respect to the ship. This means that there is only one direction of propulsion possible and that is in the direction of the nose. If the ship is travelling in the direction in which it points, figure 2, the ejection of matter will increase the speed, and if it points in the opposite direction to that of travelling, figure 3,



FIGS. 2, 3, 4

the ejection of matter will slow it down. If the axis of the ship is inclined to the path as in figure 4, the direction of travel will be altered, and the speed will be varied or remain constant according as the axis is not, or is, kept perpendicular to the path as the material is ejected.

It is clear then that ability to control the flight of the ship depends on the ability to control orientation. The principle is similar to that involved in firing a gun. It is also similar to the motions involved when a man, seated in one end of a canoe which is at rest in calm water, moves to the other end of the canoe. As he

moves forward in the canoe the canoe moves backward, and when he stops at the other end the canoe also stops. The amounts of the motions of the man and the canoe with respect to the water are inversely proportional to their respective masses.

If a wheel is mounted on gimbals in the ship, then when the wheel is turned in one direction the ship will turn in the opposite direction. A set of three wheels mounted about mutually perpendicular axes would make possible the orientation of the ship in any way desired, by suitable turning of the wheels.

Ley says that the turnings of the wheel and ship would be inversely as their masses, but this is wrong. Consider a wheel of mass 10 lb., the mass concentrated in the rim, and mounted about an axis through O with a light rod L in its own plane as indicated in figure 5. If 5 lb. masses are placed on the rod at the rim on each

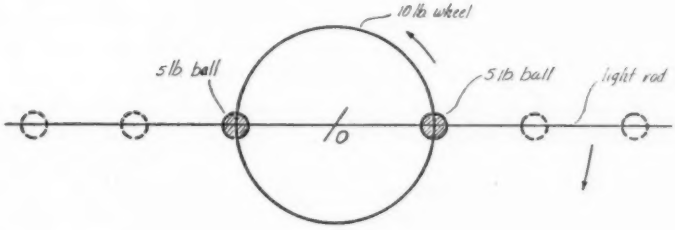


FIG. 5

side as indicated, then the mass of the wheel will be equal to the mass of the rod and weights, and a turn of the wheel through any angle from rest will cause an equal turn in the opposite direction by the rod. But if the weights are placed at two radii from O on each side, any turning of the wheel will produce only one quarter of this amount of turning by the rod. And if the weights were placed at three radii from O then the turnings would be in the ratio of 1 to 9. In all cases the masses are equal. Thus it is not the ratio of the masses that determines the ratio of turning; it is also the distribution of the masses which counts. Actually it is their moment of inertia about the axis that determines the ratio.

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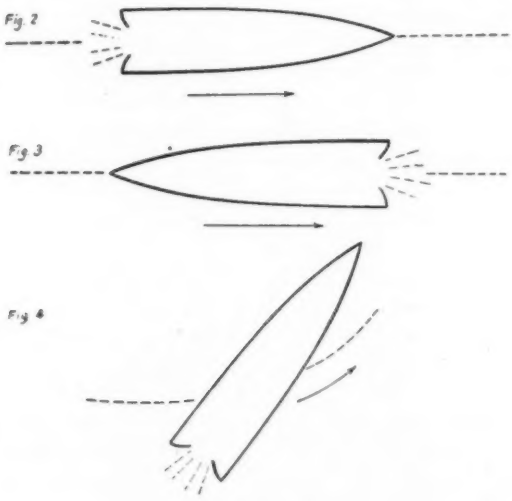

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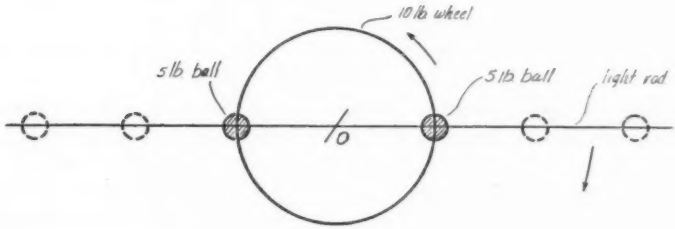

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The moment of inertia of a V-2 rocket type ship about an axis perpendicular to its length would be enormous when compared with that of any wheel which might be mounted internally and operated manually. Thus while the rotation of internal parts to effect a counter rotation of the outer frame is theoretically possible, the ship would be very unresponsive. Any friction in the bearings would make the response even more sluggish.

To get some idea of what it would be like to regulate the motion of such a ship, imagine driving a car under the following conditions: The car has an accelerator but no brakes; its steering wheel is locked in the straight-ahead position; the wheels are mounted on tires which consist of sets of steel skates, running crosswise; the car is to be operated on a glare of smooth ice; the orientation of the car can be changed very slowly by turning a heavy mounted wheel about a vertical axis in the car. This analogy is worth contemplation for it will give some appreciation of the complexity of regulating the motion of a space ship of the type suggested by Ley. No use of electronic devices or atomic energy will alter in the least the kind of mechanical reactions that have to be effected.

We see now how the problem is shaping up. We see some essential characteristics of the ships. We see that it is essential to start out with plenty of material that can be thrown off to effect propulsion, and we see the complex mechanical problem that there is to control the motion. The ratio of the initial mass when leaving the earth to that when arriving on return is called the mass-ratio, and allowance for an adequate mass-ratio is one of the most serious problems of a space-ship designer. I shall deal with the magnitude of the mass-ratio a little later, but in the meantime I want to consider another device which has been put forth and which is discussed at some length by Ley in his book. I mean the device of space stations.

Space Stations

A space station is really an artificial satellite, and it has been suggested that a series of these could be set up and that they could be used as service stations on the way to the moon. It has also been suggested that they would serve other scientific purposes.

The nearest one suggested is that of 500 miles above the surface of the earth, which is 4,460 miles from the earth's centre. It is easy to show that at this height if a body had a horizontal speed of 4.63 miles/sec., the gravitational pull of the earth on it would be just sufficient to keep it going around in a circular orbit, in the same manner as you may twirl a stone around on the end of a string. This station would be up above the earth's atmosphere. The earth's atmosphere offers a serious impediment to the take-off for a space trip because of the resistance it offers. Consequently it has been suggested that if a refuelling station could be established just outside the atmosphere that would greatly simplify matters.

But let us consider some aspects of this and other such stations. There would be no observable gravity on these stations. To some this might seem an advantage. In terrestrial laboratories, for example, we have gravity always with us, and it is impossible to isolate the effect of two bodies on each other. On the other hand gravity is one of our greatest aids. It enables us to use the beam balance and it enables us to transfer liquid from one vessel to another by pouring. Also, witness the helplessness of trying to walk when in water just at the limit of your depth, and then picture your helplessness if the water weren't there and you still had no weight.

The ozone layer of the upper atmosphere protects us from the ultra-violet rays of the sun, and on these stations there would be no protection. In the direct sun there would be intense heat and in the shade there would be bitter cold.

No suggestion has been made as to how big these stations would be, but they would have to be large enough to support a party of attendants. All supplies would have to be brought out from the earth, and this would involve regular trips. Care would have to be taken on arrival and departure not to interfere with the speed of the station. If the speed of the inner station were increased beyond 4.63 miles/sec., the station would recede to a greater height than 500 miles, and if it was reduced below 4.63 miles/sec. the station would fall below 500 miles, at the other side.

Conceivably, a station would have rotation after it was set up. In fact it is improbable that the imparting of some rotation to it

could be avoided, and it is difficult to see how it could be controlled. Space suits would have to be worn at all times.

Now regarding the inner one, it would be eclipsed during about one third of each revolution. The period of one revolution would be 1 hr. 41 min., and so for about 35 minutes during each revolution it would be eclipsed. It would be intensely cold during eclipse, and it would also be very difficult to see the station while eclipsed.

Picture now going up and making a landing at this station. In the first place the take-off would have to be timed very accurately. I presume most people have heard trainers giving calls for "go's" in trapeze acts. The timing of take-off to go to the inner station would have to be better defined than for a trapeze act. And when the height of 500 miles was reached a horizontal velocity of 4.63 miles/sec. would have had to be developed to come abreast of the station. It would be somewhat similar to two runners coming together at a common speed in a relay race.

In the magazine *Look* for August 5, 1947, there appeared an illustrated article on a trip to the moon, based on Ley's recent book. Figure 6 shows the concept of the service part of the station. This diagram shows a space ship about to enter what is called a space station's mooring socket. The space station is supposed to be developed from the first space ship which goes up as a nucleus. Details of just how this development is to take place are not given and they are not easy to imagine, but we shall pass that problem by.

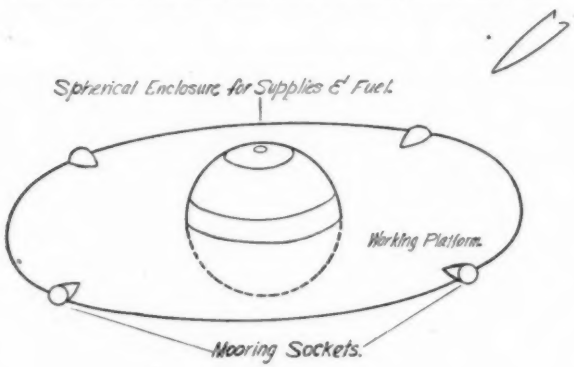


FIG. 6

The most conspicuous difficulty in operation is that the ship can accelerate in one direction only—the direction in which it points. When you park a car at a curb you apply the brakes to approach at a moderate speed, and you stop the car with the brakes just as contact with the curb is being made. Without brakes the car would crash against the curb. Since the ship can accelerate only in the direction in which it points it is like a car with an accelerator and no brakes, and the result of entering a mooring socket as indicated can only result in a crash. Even if no wrecking occurs from the impact, the momentum of the ship will be transferred in part to the station and its space velocity will be altered. The alteration may be small in any one case but from a succession of such impacts the accumulated effect might be considerable, and thus the orbit of the station would be affected. And supposing the ship did become moored successfully and became reloaded with propelling matter, how would it get out of the socket? It has no means of propelling itself backwards, and some other means would have to be found for getting it away.

Also, there is another difficulty which would arise in operation. As the station is developed by accretion, starting from the first ship as a nucleus, a rotation of the whole may be developed. In fact, it is improbable that a rotation of some kind will not be developed, and this rotation will persist. The sockets are shown as being in the periphery of a working platform, but the platform may be oriented in any manner when the ship approaches. The ship is shown as having stabilizing fins, but these will be of no avail as soon as the ship emerges from our atmosphere, and so the ship itself may be rotating as it approaches the station. It cannot be deflected from its direction of travel except by turning it suitably and ejecting material. The work of changing the orientation of the ship by a set of internal wheels would be slow and cumbersome, and so even aside from the difficulty of having no brakes it would be very difficult to control the entry of the ship into a mooring socket.

Figure 7 shows a rest unit associated with a space station. In the centre is a landing platform for small rocket ships from the space station, and the cables from this platform to the rest chambers would experience a sensation similar to that caused by gravity at the earth's surface. The starting and stopping of the

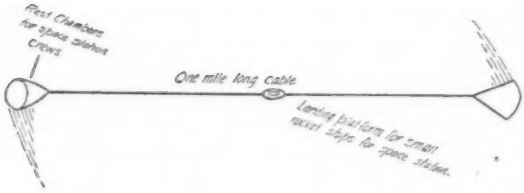


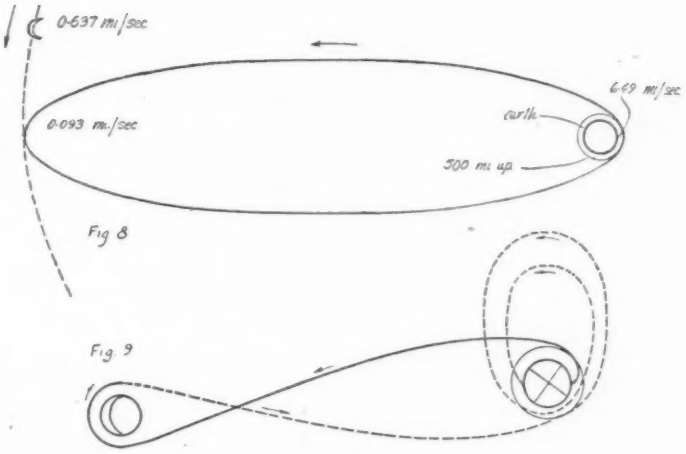
FIG. 7

rotation would be by ejection propulsion. Here again there are questions that might be raised about the difficulty of details but we shall pass them by. There is, however, one point that might be raised about this unit. Apparently it operates separately from the rest of the station, and it is difficult to see how it could be otherwise. But if it is independent it is difficult to see how drifting apart would be avoided. Any alterations of speeds due to impacts are unlikely to be the same for the different parts, and any differential that arises will be accumulative in its effect.

PATHS TO THE MOON

Figure 8 shows in principle a possible path for a body to follow in going from the earth to the moon. It rises to a height of 500 miles. The vertical velocity dies down to zero by the time it reaches that height, but it is given a horizontal velocity as it rises and if it has attained a horizontal velocity of 6.49 miles/sec. as it ceases to rise, then it will follow an elliptical path with the outer apse at the mean distance of the moon, 239,000 miles. The speed in the orbit will drop from 6.49 miles/sec. at perigee to 0.093 miles/sec. at apogee. The moon's speed in its orbit is approximately 0.637 miles/sec. As already pointed out, if the horizontal velocity of the body were 4.63 miles/sec. as it reached the altitude of 500 miles it would just go around in a circle.

The proposed method of getting to the moon can now be visualized. The ship would rise vertically from the earth and level off with a horizontal speed of 4.63 miles/sec. at a height of 500 miles. It would call at a space station and become re-loaded with more propelling material. It would then speed up to 6.49



FIGS. 8, 9

miles/sec. and travel on an ellipse until it neared the moon. Thereafter controlled motion would be necessary and it would either land on the moon or sail around it and return. A mechanism for landing was visualized in *Look*, and also the manner of effecting it. The ship has to approach the moon sternward because of the absence of braking facilities moving the opposite way. If the ship went around the moon without landing and returned to the earth, the kind of path it would follow is shown in figure 9. This in principle is the method of space travel suggested by Ley, with the modification that there may be a series of space stations and not just one.

MASS-RATIO

We come now to the question of mass-ratio required. A few years ago I considered this problem and published a paper* containing my results. I worked out a solution on the following basis: The ship left the earth and was propelled by mass expulsion in a vertical direction, this direction being such that, if unaltered, it would intercept the moon at the distance of the moon's orbit;

**Philosophical Magazine*, Ser. 7, vol. 31, pp. 24-34, 1941.

ejection of mass was at such a rate that it would produce an acceleration of 2g, and ejection lasted until the speed attained was just sufficient to carry it by the equipotential point between the earth and the moon; on nearing the moon mass-ejection was again used at the rate 2g to bring the ship to rest on its arrival at the moon's surface; the return to the earth was by the reverse process; the speed of ejection used was 1 mile/sec., and no allowance was made for air resistance on either the outward or the inward journey.

The mass-ratio obtained was 2.0×10^9. This result has been criticised as unreasonably high. The mathematics has never been questioned and so the assumptions made are the things to be examined. We shall take them in turn.

An acceleration of 2g may be regarded by some as low. Airmen in dive-bombing quite commonly experience up to 4g, and experiences are on record I believe of accelerations up to 7 or 8g. I have talked with a pilot who had considerable experience in the recent war, however, and he considered a man would be incapable of much functional control at 3 or 4g, and at 7 or 8g he would experience blackout. Control of the ship at all times would be important and so an acceleration of 2g does not seem unreasonable. Just recently there has been reported a special suit for counteracting the blackout effect of high acceleration, and this may make the use of higher g's possible. However, the point is not a very important one. In the calculations for the curved path as suggested by Ley and others I have made no restriction on the number of g's to be used.

An ejection speed of 1 mile/sec. has been criticised as too low. Ley has suggested a speed of 3,000 meters/sec. as obtainable, and as about the limit obtainable with liquid oxygen. This is roughly 2 miles/sec., and its use would replace the mass-ratio above by its square root, viz. 4.5×10^4. In my solution as much mass-ratio was needed for the return to the earth as for the outward trip to the moon. Actually in travel this would not be so for the atmosphere would act as a brake on the return, and would act as an impediment on the outward trip. But these two differences would to some measure neutralize each other, and any underestimate of the advantage could be regarded as an operating safety factor.

Consider, now, a trip to the moon as envisaged by Ley and others. The take-off occurs somewhere on or near the earth's equator, and there the eastward speed is 0.288 miles/sec. The ship rises by mass ejection so that it will attain a height of 500 miles, and by the time it has reached that height it must have attained a horizontal speed of 4.63 miles/sec. The surface horizontal speed of 0.288 miles/sec. at the earth's surface will have fallen off to 0.256 miles/sec. at an altitude of 500 miles, because unless interfered with the product of the horizontal speed by the distance from the earth's centre remains constant. It is necessary therefore to impart a horizontal speed of $4.63 - 0.26 = 4.37$ miles/sec. by mass-ejection. Also, in order to do so it will be necessary to change the orientation of the ship from upward to eastward pointing on the way up to the 500 mile level, and this would have to be accomplished by turning some inward mass. Even if there were no atmosphere to resist, the initial vertical velocity to rise 500 miles is 2.33 miles/sec. Hence a total velocity of 6.70 miles/sec. would have to be obtained from mass-ejection to come abreast of the first space station. With the matter ejected at 2 miles/sec. this would require a minimum mass-ratio of 28.5. But this is with making no allowance for air resistance, and with air resistance allowed for the ratio would be much higher.

To go on from the space station would require a speed of 6.49 miles/sec., which is 1.85 miles/sec. greater than that of the station. The velocity of escape for the moon is 1.5 miles/sec. and so the mass-ratio factor for this part of the trip would be at least $e^{1.7} = 5.47$. Hence the total mass-ratio to reach the moon would be $28.5 \times 5.47 = 155.9$. If the same mass-ratio were assumed for the return trip, the mass-ratio for the complete trip would be $155.9^2 = 2.3 \times 10^4$. This result is in reasonable agreement with modified result of my previous paper. For in obtaining it the assumption was made that the initial upward velocity of 2.33 miles/sec. was imparted without limit as to the number of g's required.

There is an interesting point of difference between the two paths. In my former paper the path was straight and in the journey just considered the path is curved. Some of the curves would be natural but some of them would be controlled, and in

the matter of controlled curves there is an important difference between space travel and the terrestrial travel with which we are familiar. If you drive a car around a curve on a smooth road you may shut off your engine and get a change of direction without change of speed and at no expenditure of fuel. But in a space ship the only way to achieve a change of direction even without change of speed is by mass-expenditure in a suitable direction. There is thus a drain on mass resources for any kind of control of the motion, in magnitude, direction, or both.

In their endeavor to keep the mass-ratio down, would-be space travellers have assumed their ability to get back to the earth safely by a series of braking ellipses in the earth's atmosphere as indicated in figure 9. At each perigee passage the speed is reduced, and as the perigee speed is reduced the apogee distance is reduced. The result is a settling down nearer and nearer to the earth. But that one will be in a path which will settle down satisfactorily in this manner, after he has succeeded in getting away from the moon, is expecting a lot from luck. Ability to adjust and to regulate in any manner deemed necessary is essential, and also it would only be reasonable to count on getting back to the earth with some reserve of mass-expenditure.

V-2 Rocket Experience

What are the results obtained with V-2 rockets, in altitude work, to date? At White Sands Proving Ground captured German V-2 rockets are being used for exploring the upper atmosphere, and reports of the results are given in *Sky and Telescope*, February 1947, and in *The Scientific Monthly*, June, 1947, by members of the Naval Research Laboratory, Washington, D.C. The rockets measure almost 47 feet in length and have a diameter between five and six feet. They have attained a maximum height of a little over 100 miles. On the upward flight of the October 10 rocket the maximum speed was about 1 mile/sec. and occurred at an altitude of about 80 miles. Some of the rockets exploded before reaching the earth on return and some of them returned intact. The latter produced craters on impact. The one of June 28 produced a crater 80 feet across and more than 30 feet deep. Some rockets have rolled and tumbled during their flight.

When passing through the atmosphere on braking ellipses as suggested, the perigee velocities within the atmosphere would be very high. Moreover the ship would not be turning so as to be nose-on at all times without control, and it is difficult to see how control could be exercised to keep it nose-on. Also, unless it were travelling nose-on, it is difficult to see how tumbling could be avoided.

Atomic Energy

A query, rather naturally, will no doubt occur to many minds when considering space travel. Why not use atomic energy? The suggested solution, however, is not as simple as it looks. While atomic energy is terrific in its extent, it is not energy but the momentum of the ejected material which counts in space propulsion. The energy of an atomic bomb is enormous but the momentum of ejected material would be moderate. For while the speed of ejection would be high the mass ejected would be low. Moreover, as a pile now functions it would be necessary to take along a great amount of non-propelling material in order to have atomic reaction. Also it would be necessary to insulate the crew very heavily for protection against radiation. So the prospect of using atomic energy direct is not encouraging.

Ley has suggested the using of water for mass propelling matter, and the use of atomic energy for ejecting it. This scheme would give more momentum for a given consumption of atomic energy, on account of the greater massiveness of the water, but there would be a decrease of efficiency. Moreover the problem of extra dead weight of material for functioning of the atomic reaction and for insulation would still be present, and it would be aggravated by the load of water to be carried along. Ley goes on to suggest that it would not be necessary to go to the moon with sufficient water for the return trip, as enough water for this purpose might be found on the moon. I think a venture based on this hope would be a very risky gamble.

However, developments of atomic energy have only begun, and it is too early to prophesy what may be done with it.

Summary

To sum up, the following principles should be kept clearly in mind when considering the problem of space travel.

1. Space travel control is different in character from control of travel of any terrestrial sort with which we are familiar. For the latter all we need is energy—land, sea or air will afford a medium of traction—whereas in space travel we have to provide the equivalent of a tractive medium as well as energy for propulsion.

2. Every manner of control of motion in space travel—speeding up, slowing down or changing direction—requires the expenditure of energy and propelling mass, whereas in terrestrial travel the tractive medium alone will afford change of direction without any expenditure of energy.

3. The mass-ratio requirement accumulates according to the exponential law, no matter for what purpose the expenditure of mass is to be made.

4. In space travel, unless the total thrust from mass ejection passes through the centre of mass of the ship some angular motion will be set up, and even though small this angular motion will accumulate for there is no atmosphere to damp it out.

On the other hand the situation regarding the suggestions that have been made for solving the problem are as follows:

The descriptions available for many of the suggestions are lacking in detail. Some pictures of a space station arising from a first space ship as a nucleus are given, but the manner of building it up is not given. Sufficient mass is allowed to get up to the station but no provision is made for making the return trip, and it is difficult to see how provisioning could be a one-way process. To produce the rest stations it is suggested that a ship be divided in two about equal parts, that these be connected by a strong cable and then be given a push apart by any means. The cable is to have a safety factor of strength, but strong is only a relative term and no suggestion is made of what would be done if the cable snapped when it became fully extended. The danger of being hit by meteors is recognized and it is suggested that patches could be put over small holes in the living compartment to prevent escape of atmosphere. It is admitted that the leakage might be so great before the holes were sealed that the atmosphere was no longer sufficient, but no suggestion is made of how replenishment would be effected. There is no statement of how large the station would be, but there is an attractive picture painted

of what could be done in scientific laboratories and observatories and so the suggested size is considerable. In an August, 1947, newspaper there appeared the photograph of a scientist who was reported to have said that the construction of a man-made satellite revolving about the earth is possible with engineering knowledge now available. If this is so we shall await details of the method of construction with interest.

I have shown that the manner of arriving at a space station as described in a recent article in *Look* is impracticable; I have also shown that the orientation of a ship in space cannot be controlled by the principle suggested by Ley, and that while controllable by a related principle the ship is much less wieldy than suggested.

The problem of space travel is fraught with many difficulties. It should not be too unreasonable to suggest as a preliminary step, by those who believe it possible, a demonstration of the ability to get outside the earth's atmosphere in a ship, manoeuvre there arbitrarily, and then return safely to the earth.

Addendum

From radio broadcasts it has been apparent for some time that Dr. Dinsmore Alter, Director of the Griffith Observatory, is a proponent of the possibility of travel to the moon. While this paper was in process of being written I saw in Popular Astronomy a review of a pamphlet by him entitled *Atoms, Rockets and the Moon*, and I put in an order for a copy. The copy arrived after my manuscript was completed, and while there is nothing in it which makes any modification of the manuscript necessary it has some features which are worth comment.

The pamphlet consists of eight chapters. The first four deal with the development of nuclear physics, culminating in the production of the atomic bomb. This is a fascinating story of achievement and is well written. The last four deal with the future of atomic energy and the problem of space travel. They also are well written, but they are speculative.

Dr. Alter paints a glowing picture of the possibilities which will follow the establishment of travel to the moon. He points out what will be possible when observatories and laboratories are established there, and he also makes a claim for the advantages which the moon will offer as a military base as between contending

nations on the earth. All this by way of promoting a public interest in the value of establishing travel to the moon.

Regarding method of travel he does not go into details, but he outlines some principles. He suggests the use of spherical ships instead of streamlined ones. These would be propelled by mass expulsion from a battery of jets pointed in one direction, but the orientation of the sphere would be modified by ejecting matter from a set of tangential jets distributed over the surface of the sphere. The path followed would not be a direct one, but would be similar to that suggested by Ley—a controlled spiral orbit. To get away from the earth a set of 'huge helicopter propellers' would be attached to the sphere, to operate in getting through the earth's atmosphere when leaving and also to operate on nearing the earth when returning. When near the moon the ship would be put in a circular orbit about it, and landing on the moon would be effected by landing smaller spheres equipped similarly to the large one, except that the helicopter attachments would be absent.

Dr. Alter gives no quantitative calculations and he makes no reference to the mass-ratio requirement. After outlining the type of ship as just described, he suggests that a ship to take three or four people to the moon might consist of a sphere 12 to 15 ft. in diameter. He says the problem of constructing such a ship is difficult, but he hopes not impossible of solution. That hope, I fear, is not well founded.

The basic load on returning to the earth would consist at least of the original sphere, its occupants and equipment, and a set of attached helicopters. For all the controls envisaged by Alter a mass-ratio of 1,000 would not be high. Picture then a sphere large enough so that it would hold propelling matter 1,000 times the mass of itself, equipment and helicopters combined. A 15 ft. sphere appears entirely inadequate.

Here again a reasonable first step to expect is the practical demonstration of a ship, constructed on the suggested plan, that can be taken outside the earth's atmosphere, manoeuvred there arbitrarily, and then returned safely to the earth.

In his chapter on the *Peacetime Uses of Atomic Energy* Dr. Alter stated that "many of the ideas talked and written about so glibly today seem incapable of actual accomplishment."

That statement is equally applicable to the ideas on space travel.

MINUTES OF THE ANNUAL MEETING OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The fifty-eighth annual meeting was held in the McLennan Laboratory on Friday, January 16th, 1948. In the absence of the President, Dr. Frank Hogg was voted to the chair. Members were present from Windsor, Ottawa and Montreal in addition to those from Toronto.

The minutes of the last annual meeting, having been printed in the JOURNAL, were taken as read and adopted.

Scrutineers—Miss Budd, with Messrs. Hargraves and Sherrick, were appointed scrutineers, and were allowed to retire for the counting of ballots.

Reports—The annual reports of the General Secretary, General Treasurer, Librarian and Editor were presented. These appear in full in the JOURNAL.

Scrutineers' Report—Notice having been given of a proposed change in By-law IV by striking out the words, "The fee shall be $2.00 per annum," and substituting therefor the words "The fee shall be fixed from time to time by the General Council" and also, regarding Junior Members, striking out the words "one dollar" and substituting the words "one-half the amount of the regular fee," the scrutineers reported that the vote in favour of the change was 334, and against 26. The chairman therefore declared the amendment to the By-law carried.

The election of officers for 1948 resulted as follows—Total number of ballots cast 361; of these 306 were marked for the entire slate as submitted, and the balance with some slight modifications. The complete list of officers of the Society is given on page 91.

Thanks—After the thanks of the meeting had been extended to the Officers for their service during the past year, the meeting adjourned.

H. W. BARKER, *Recorder.*

Report of the General Secretary

The past year has been a most active one. 1946 showed a great increase in the interest and activities of the Society over previous years. This progress has been well sustained during 1947. Among the important events is the addition of three new centres at Saskatoon, Guelph, and a second group in Montreal, composed of French members.

Saskatoon—Professor Petrie of the University of Saskatchewan has been the moving spirit in establishing the Saskatoon Centre. Mr. J. H. Irwin, B.A., B.Ed., is the first President and Dr. J. E. Johns, a son of our immediate Past-President Dr. A. E. Johns, is a member of council. They start with 35 members.

Guelph—Early in the history of the R.A.S.C. Guelph had a fairly active group but for various reasons it was disbanded 26 years ago. Mr. Westoby, one of the early members, after visiting the Toronto Centre at their meeting last fall at the David Dunlap Observatory, became quite enthusiastic about reviving the interest in astronomy in Guelph. He has already sent in 75 nominations for membership. The O.A.C. President, Mr. Reek, has been most helpful and we are indebted to him for providing accomodation for holding meetings at the College.

Montreal—Some of the council members of the Montreal Centre have been of the opinion for some time that a new section should be established for purely French-speaking members. The great proportion of the population of Montreal being French, this proposal should be attractive and add much to the interest of the subject of astronomy in Montreal. To avoid confusion in identification, the Council when authorizing the formation of the new centre, suggested that this group be known as the Société Royal d'Astronomie du Canada, Le Centre Français de Montreal. Mr. DeLisle Garneau who has been so successful as chairman of the observation committee of the Montreal Centre has been named as President.

The Society has suffered heavily by death during 1947. Mr. Boyd Brydon died at Victoria, B.C. Mr. Brydon occupied the office of First Vice-President in 1946 and in the natural succession would have been our President this year. Recognizing his failing health he resigned his office before the election in 1947. His place will not be filled easily. He was a constant and brilliant contributor

to the JOURNAL. Mr. A. F. Miller passed away on February 2nd. He was one of the founders of the Society. Mr. D. J. Howell who has lived in England for a great many years died this year. Mr. Howell will be remembered by only a few of the older members. He was one of the founders of the Society. With his passing the last charter member is struck off the roll. The Toronto Centre mourns the loss of its oldest active member, Mr. H. G. Duncalfe, a gentleman whose keen scientific mind and lucid expression made him a popular speaker at the Toronto meetings during many years.

Although we were unsuccessful in our efforts to induce the Federal Government to increase our grant (which was reduced during the depression and never restored) we feel constrained to thank and commend all those of our members across the country who wrote and visited their Members of Parliament presenting our case. We desire to mention particularly our Treasurer, Mr. J. H. Horning. Mr. Horning spent many weary hours preparing statements and writing letters. The centres are urged to continue the pressure on the Members of Parliament in their district.

It will be noticed that advertising is appearing for the first time in our publications. The General Council authorized the solicitation of advertising during the year and a modest beginning has been made. We are hopeful that this addition to our sources of revenue may grow.

The circulation of the Handbook is now just short of 6,000. Its popularity is remarkable.

The attached report gives details of our membership which continues to increase steadily. It now stands at 1,818.

Clerical work and correspondence increases with the membership. With our present staff and facilities we find it difficult to keep up. Until funds are more abundant we ask your indulgence if your letters and orders are not answered promptly.

MEMBERSHIP ON DECEMBER 31, 1947

	1946	1947
Toronto Centre	273	291
Montreal "	290	283
Winnipeg "	35	34
London "	37	28
Edmonton "	51	40
Hamilton "	51	47
Vancouver "	66	56

Ottawa "	65	69
Victoria "	119	92
Quebec "	88	97
Windsor "	59	58
Guelph "		75
Montreal, French S.		30
Saskatoon Centre		35
Members unattached to Centres		
in Canada	109	130
in the United States	312	325
in other countries	23	40
Life Members who are not included in Centres	24	23
	1602	1753
Additional Subscribers to Journal	62	65
University of Toronto	75	75

E. J. A. KENNEDY, *General Secretary.*

REPORT OF THE LIBRARIAN

During the year 1947 periodicals were received:

From Canada and the Empire	61
From the United States of America	62
From Other Countries	45
Total	168
The number of books loaned from the shelves was	197
Expenditure: for new books	$17.85
for binding periodicals	$44.52

The new books added to the library were: *Galaxies*, by Harlow Shapley, *Between the Planets* by F. G. Watson, *Telescopes and Accessories* by Dimitroff and Baker, *A Primer for Star-Gazers* by H. M. Neely, and *Making your own telescope* by A. Thompson.

Jamieson's Celestial Atlas, published in 1822 has been long on our shelves, and continues to be much used; Mr. W. R. Sherrick, seeing the need, has had it bound at his own expense and returned it to its place in the library. Through the kindness of the Ontario Department of Education we have received from their stock thirteen sets of Dr. Chant's fine series of 100 lantern slides. We have written all the Centres offering each one a set and have been sending them on as replies came in.

D. W. BEST, *Librarian.*

REPORTS OF SECRETARIES OF THE CENTRES

Toronto Centre

Expansion of activities designed to introduce Astronomy to the public as an interesting hobby marked the Centre's programme during 1947. In addition to four monthly "star nights" on the University of Toronto campus, four others were arranged in other parts of the city where telescopes were to be set up for observation of the moon, planets and stars. Resumption of the annual Canadian National Exhibition afforded the Society an opportunity to resume its programme of having telescopes available there. Instruments were set up on 11 of the 14 nights. Three nights were entirely clouded out. Altogether more than 4,000 Exhibition visitors accepted our invitation to "sky-see" and as several telescopes were in use most nights, the total estimated "looks" reached more than 10,000. Through the kind co-operation of The Toronto Daily Star, a four-page illustrated leaflet, entitled "Sky-Facts," was printed and distributed to each visitor at the Society's telescopes.

The Telescope Makers' group, under leadership of Mr. Raymond Pearce, now has more than 50 members. Several members have completed instruments, two of these being used at the Exhibition. As a result of inquiries from Boy Scout and Girl Guide groups for aid in planning tests for Astronomer Badges, the Centre set up a group of volunteers to instruct and test the Guides and Scouts.

The Council and membership of the Centre learned with deep regret of the passing during the year of the last two Charter Members. Mr. Allan Frederick Miller died at his Toronto home and Mr. David Howell passed away in England. Among other members who passed on during 1947 were Mr. Tracy D. Waring, a former Secretary of the Centre, and Mr. Henry G. Duncalfe, a member of Council, who died in his 92nd year.

Meetings: Eleven regular lecture meeting were held during 1947, as well as a joint meeting on November 29 with the Royal Canadian Institute. The Council held one formal meeting, and the Executive Committee met on several occasions. Subjects and

speakers at meetings, held in the McLennan Physics Laboratory of the University of Toronto, except where otherwise noted, were as follows:

February 11,—Dr. A. Vibert Douglas: "Zurich and London when the Sun was in Taurus."

February 25,—Dr. Ralph E. Williamson: "What American Astronomers are Doing—A report on the recent meeting of the American Astronomical Society."

March 11,—Dr. Sydney H. Gould: "Gulliver and the Moons of Mars."

March 25,—Mr. Andrew Thomson: "Advances in Meteorology During the War Years."

April 8,—A programme of motion pictures of astronomical interest.

April 22,—Dr. Frank S. Hogg: "Rockets and Astronomers."

May 30, June 27, July 25 and September 26,—"Star Nights" with telescopes on the University of Toronto campus.

June 25,—Neighborhood "Star Nights" were held in Millwood Road Community Park, Leaside, and in West Toronto opposite Runnymede Public Library. (Similar events planned for Eglinton and Riverdale Parks on July 23 were cancelled by cloudy weather.)

October 7,—Dr. R. E. Williamson: "The Anatomy of Stars—What's under their surfaces."

October 21,—Members' Night at the David Dunlap Observatory, Richmond Hill.

November 4,—Mr. F. K. Dalton: "Studying the Heavens as a Hobby."

November 18,—Dr. C. S. Beals: "What's in the Space Between the Stars?"

November 29,—Dr. Charles H. Smiley: "Solar Eclipses, Past, Present and Future." (A joint meeting with The Royal Canadian Institute, held in Convocation Hall.)

December 2,—D. K. Norris, R. Tanner and F. L. Troyer: "What's New in Astronomy—Some Developments of 1947." (The annual business meeting followed).

Membership: As of December 31, there were 297 members on the roll, of whom 10 were life members. There were 51 new members elected during the year, and 25 were removed for various reasons, leaving a net gain of 27.

FREDERIC L. TROYER, *Secretary*.

OTTAWA CENTRE

During 1947 three council meetings, five general meetings, and an "At Home" were held. The general meetings were as follows:

January 30,—Wing Commander K. C. Maclure, B.Sc.: "Polar flights of the *Aries*."

February 13,—Prof. F. S. Hogg, Ph.D.: "Our turbulent universe."
February 27,—H. W. Stilwell: "Mapping our northland."
March 13,—J. Dainty, M.A.: "Atomic energy and stellar evolution."
March 27,—W. S. McClenahan, B.A.: "How we tell the time."

April 10, Dr. Beals and his staff entertained members and their friends at the Observatory.

The membership is at present seventy-one. The Society lost one member by death and gained five new members. The Centre joined the Canadian Scientific Film Association. Letters were written to the local members of Parliament asking their support to a request for an increased grant to the Society. The answers were sympathetic if not encouraging.

C. B. HICKS, *Secretary.*

HAMILTON CENTRE

During the year the Hamilton Centre held seven regular meetings in the Art Gallery, one meeting, a visit to David Dunlap Observatory at Richmond Hill, Ontario, one Field Night, and two Council meetings.

January 2,—Dr. H. G. Thode: "Neuclear Energy."
February 6,—H. B. Fox: "Corrosion and Your Telescope."
March 6,—Prof. W. H. McNairn, M.A., Ph.D.: "Is the Universe Running Down."
April 3,—A visit to David Dunlap Observatory at Richmond Hill, Ontario.
May 1,—W. S. Mallory, M.A.: "Gravitation."
June 23,—Field Night: Held on the grounds of the McMaster University. The most favourable weather in many years was enjoyed. The out-door meeting attracted a large crowd. Four reflector-type and three refractor telescopes were in use. Coffee and doughnuts were provided by W. T. Goddard.
October 2,—Social Evening: H. B. Fox and O. J. Paton performed several experiments in physics to an interested audience. Several moving pictures of interest to the amateur astronomer were shown. At the conclusion of the meeting refreshments were served by the ladies of the executive.
November 6,—R. E. Williamson, M.A., Ph.D.: "The Anatomy of Stars."
December 4,—W. D. Stewart: "A Visual Introduction to Astronomy."

Membership: As of December 4th, 1947, there are 47 members on the roll, one being a life member. Mr. Frank Kroeger a member of this centre for many years has left the City for Capetown, South Africa.

GEORGE MURCHIE, *Secretary.*

Winnipeg Centre

Eight regular meetings have been held in Lecture Theatre B., University of Manitoba, with a Observation Night in May, and three Council Meetings. The general meetings were reasonably well attended as was the Observation Night.

January 15,—Dr. L. A. H. Warren: "The Fundamentals of Astronomy."
February 12,—Mr. D. M. Robertson: "Modern Weather Forecasting."
March 3,—Mr. A. V. Piggott: "The Case for Astronomy."
April 9,—Mr. H. Rasmussen: "The Manufacture and Testing of Optical Components for Use in Astronomy."
May 14,—Mr. L. Koser: "Some Reflections on Jupiter." Mr. H. Rasmussen: "Spectroscopy from the Photographic Aspect."
May 15,—Observation Night.
October 8,—Mr. Weston C. Fisher: "Relationships between the Work and Research in Radio-Engineering and those of Astrophysics."
November 12,—Mr. H. E. Beresford: "The History of Map Making."
December 10,—Mr. D. R. P. Coats: "Sun-spots."

In addition to the lectures, Mr. Koser's "Astronomy in the News" was an interesting and instructive feature of each meeting. The monthly Bulletin, "Starlight", has appeared regularly and has served admirably to focus our attention on the coming meeting, while giving a resume of the past one, together with much material of current interest.

During the year the Centre has had 34 paid up members. The Centre suffered a sad loss in the death of Professor W. A. Anderson early in 1947.

Beverley Sharman, *Secretary.*

Montreal Centre

The season 1946-7 proved a satisfactory one in all respects. Membership in the Centre was well maintained, and at the close of the season there were 283 members on our roll, as compared with 281 at the end of the previous season.

We were again fortunate in obtaining excellent guest speakers for our general meetings, a highlight of the season being the visit, on March 28th, 1947, of Dr. Bart J. Bok, Associate Director of Harvard Observatory. There were seven general meetings of the Centre during the year, with an average attendance of 89 persons per meeting, and five meetings of the Council were held.

The following speakers were heard at general meetings:

October 17,—Dean Henry F. Hall: "Astronomy and English Literature."
November 21,—Dr. John Stanley: "Story of the Flying Bomb."
January 20,—Dr. A. Vibert Douglas: "Life and Work of Sir James Jeans."
February 20,—Mr. R. Meldrum Stewart: "Time and Timekeeping".
March 28,—Dr. Bart J. Bok: "Matter in Interstellar Space."
April 24,—Dr. W. Rowles: "The Sun."
May 8,—Closing Social—Symposium on "The Ten Most Interesting Stars."

In addition to these meetings, an introductory course of lectures on "The Solar System" was given by members of the Centre, with an average attendance of 80 persons per meeting. These lectures were not considered official meetings of the Centre. Speakers and subjects in this series were as follows:

November 7,—Mr. F. DeKinder: "The Solar System."
December 5,—Mr. E. Russell Paterson: "The Sun."
January 9,—Mr. J. W. Duffie: "The Moon."
February 6,—Dean Henry F. Hall: "The Inner Planets."
March 6,—Mr. C. M. Good: "The Outer Planets."
April 10,—Miss I. K. Williamson: "Comets and Meteors."

The observational work of the Centre continued to expand and new attendance marks were set at the Ville Marie Observatory, where observation meetings were held every Saturday evening throughout the season. Practical observations were carried on regularly in many fields, and members of the Centre were able to make valuable contributions to the science.

It is with considerable regret that we note the death, in February, 1947, of Monseigneur C. P. Choquette, Honorary President of the Montreal Centre for many years, and a member of the Centre since the early days of its existence.

J. W. DUFFIE, *Secretary.*

REPORT OF LIBRARIAN

The current year has been a most successful one for our Library, not only for the increase in circulation and the number of volumes added but also for their quality, variety and usefulness. This was made possible through gifts of books and generous donations to the "Library Fund," thus allowing somewhat more expensive books to be purchased. Extra copies of the more popular books were acquired, helping to reduce excessive wear when only one copy is available. Repairs and rebinding were minor items due to a considerable amount done the previous year.

Total circulation of books was 365—an increase of 17%, and that of periodicals was 120—a slight decrease.

C. M. GOOD, *Librarian.*

Sixth Annual Report of Observation Committee

1947 was a year of notable activity both in observations and telescope making. The attendance at Ville Marie Observatory also showed a marked increase over the previous year. 1308 people signed the Guest Book. Fifty Saturday meetings of the Montreal Centre resulted in an attendance of 1055.

Sun-spot observations—20 members contributed a grand total of 216 observations during a 12-month period and recorded 1829 groups, containing 16,402 sun-spots. This great solar activity was reflected in the Aurora Borealis. Miss Williamson, in charge of this section, reports that a total of 33 monthly and 100 descriptive reports covering 65 displays were forwarded to Dr. Gartlein at Cornell University. Fifteen members contributed in this field. Mr. Morgan made a special study of the rotation of sun-spots.

248 estimations of magnitude on 240 variable stars were made and monthly reports sent into the A.A.V.S.O. The Orionid, Leonids and Perseid meteors were observed by groups of members. Copies of all these observations were sent to Dr. Peter M. Millman at the Dominion Observatory, Ottawa.

With Mr. Henshaw 16 members were engaged in telescope making during the year. Most of their instruments are now in operation. In addition, Mr. Donnelly has made a mirror grinding machine with which he is now working on the 12" reflector.

The partial eclipse of the sun of November 2, 1946 was timed, recorded and photographed, 12 members participating. Two observers recorded 13 high flying migratory birds across the disk of the sun during the spring and six recorded 46 during this fall. As was mentioned last year, this work was carried out in response to an appeal made by the Department of Ornithology of Harvard College.

Elaborate plans were made for the Centre's Third Annual Star Night on September 22nd or 23rd. Unfortunately, because of unfavourable weather conditions, the event had to be called off.

Last but not least, I wish to report great activity in the Messier Club for adult members which was formed late last Fall as a counterpart of the Asteroid Club for children of members. Fifteen members are now actively engaged in the search for the 103 objects catalogued by Messier.

DeLisle Garneau, *Director of Observations.*

Victoria Centre

During the year 39 new members were added to the Centre, whereas 15 were lost for various reasons. The total membership now stands at 143, with a net gain during the year of 24; and includes 5 life members and 8 junior members.

During 1947 seven regular meetings and five summer course meetings were held. For the program of Summer Evenings with

the Stars there was an enrolment of 144 newcomers to the Centre. Of these, 28 have since joined the Centre as regular members.

JEAN K. MCDONALD, *Secretary.*

LONDON CENTRE

The London Centre held eight regular monthly meetings, and one informal picnic during the year 1947. This year the Centre was proud to celebrate the twenty-fifth anniversary of its founding and its affiliation with the Royal Astronomical Society of Canada, at which time we were favoured by a very fine address by Dr. Helen Hogg of the Dunlap Observatory Staff.

Meetings held during the year were:

January 10,—Silver Anniversary Dinner. Dr. H. R. Kingston: "Twenty Five Years in Retrospect." Dr. Helen S. Hogg: "Beacons of the Milky Way."

February 14,—Dr. H. R. Kingston: "From a Merry Go Round We View the Skys." Dr. O. O. Fisher: "The Paricutin Volcano."

March 14,—Dr. H. R. Kingston: "The How, When and Where of the Changing Skys." Mr. Omar Kilburn: "Grinding Lenses and Making Mirrors."

April 11,—Dr. H. R. Kingston: "Determining the Date of Easter Sunday." Dr. G. Calder: "Methods of Lake Navigation." Dr. A. J. Watt: "Use of Binoculars in Constellation Study."

May 9,—Dr. H. R. Kingston: "Right Ascension and Declination." Dr. G. R. Magee: "Astronomical Paradoxes." Rev. W. G. Colgrove: "The Pretty Ways of Providence."

June 13,—Picnic. Mr. J. Middlebrook: Photographic slides and display.

October 10,—Dr. A. H. Johnson: "Copernicus." Rev. W. G. Colgrove: Demonstration of Pluto's Orbit.

November 14,—Dr. H. R. Kingston: "Stars that Pass Near Our Zenith." Dr. R. H. Cole: "Relativity."

December 12,—Annual Meeting, Election of Officers. Social evening. Dr. H. R. Kingston: "Astronomical Predictions in Gulliver's Travels."

Particular thanks to the members go to Dr. H. R. Kingston, recently appointed Dean of University of Western Ontario, for his basic astronomy talks which preceded most of the monthly lectures.

A. EMSLEY, *Secretary.*

EDMONTON CENTRE

All regular meetings have been held in the Arts Building through the kindness of the University authorities. The annual meeting

took the form of a dinner at the Corona Hotel. The attendance varied from 20 to 46 members and visitors.

Handbook talks were given by Dr. Campbell.

The main papers have been as follows:

December,—Dr. W. H. Johns: "Nature and the Ancient World."
January,—Miss Sidney Jones: "Jupiter."
February,—Mr. E. S. Keeping: "The discovery of Neptune."
March,—Mr. W. E. Mjolsness: "The Making and Testing of Amateur Reflecting Telescopes."
April,—Dr. D. B. Scott: "The Glass Giant of Palomar."
May,—Mr. Alec Stockwell: "Tycho Brahe."
October,—Mr. E. H. Gowan: "The Electron."
November,—Mr. L. E. Gads: "Maps."

The roll of the Centre now consists of 54 regular members and two associates. The Library has been well patronised.

E. H. Gowan, *Secretary.*

Quebec Centre

The Quebec Centre operates its temporary observatory with the support of the Provincial Government. This co-operation dates back to September 1943, when it was proposed as tenative, but it is only during 1947 that a real progress has made toward its definite regulation. From this point of view, the year just ended can be considered as a most important one in our Centre's life.

General meetings have been held regularly during the year. Here are the dates and programmes:

January 11,—Roland Bernier: "Mouvements du globe terrestre."
February 22,—Claude Frémont: "Le spectroscope nous livre ses secrets."
March 22,—Gustave Lévesque: "A quand la fin du monde."
May 24,—A meeting devoted to the showing of the astronomical pictures.
June 22,—The observatory was open to the public during afternoon and evening.
October 10,—Chs.-A. Giroux: "Configurations des planetes, d'après, l'American Ephemeris."
December 5,—The annual meeting. Roland Bernier: "La Mythologie dans l'astronomie."
At each of the inside meetings, Mr. Giroux delivered his regular review of the sky of the month.

During the year 1947, our membership showed a slight increase: 97 against 88 for last year. At the observatory, 1,120 visitors registered in our guest book. A total of 747 estimations of variable stars was made from May to November. Every occultation of star brighter than magnitude 6.55, visible at Quebec from July 1 to September 15, was computed from the elements given in the American Ephemeris. Out of a total of 18 possible, only 5 were registered chronometrically. Mr. Giroux was in charge of this work. Tests were made on the 16-inch reflector and the wooden tube was not found to be rigid enough.

Mr. Geo.-E. Gagné has made interesting compilations on weather cycles. Our *Comité du Télescope*, directed by Léon-D. Descarreaux, has performed its preparatory work during the year and is now ready for complete activity.

The *Graphique du Ciel*, graciously edited in French by the Maryland Academy of Sciences, in Baltimore, is increasing its popularity. During the year, 2,500 copies were sent out.

PAUL-H. NADEAU, *Secretary*.

WINDSOR CENTRE

Nine public meetings and one council meeting were held during the year 1947. These meetings, with two exceptions, were held in the Art Gallery of Willistead Library. At each meeting a member has described the astronomical events for the following month. Weather permitting, observations with the four-inch refracting telescopes, set up in Willistead Park, followed the meetings. Mr. G. F. Spracklin arranged other observations at convenient locations.

We had some 58 names on the membership rolls for 1947. We are pleased that the members are often accompanied by friends and guests. The local newspaper, "The Windsor Daily Star," carries an announcement on the Saturday preceding each meeting. Publicity is also carried throughout the Secondary Schools and many students are members or guests.

The Windsor Centre is fortunate in having the excellent co-operation of the Detroit Astronomical Society. Three Detroit members are on the Windsor council. Another Detroit member, Professor E. R. Phelps, Ph.D., of Wayne University, kindly

consented to accept the post of Honorary President of our centre. The secretary of the Detroit Society, Mrs. Margaret Back, renders every possible assistance. The June meeting of the Detroit Society was held at the Cranbrook School, Bloomfield Hills, Michigan. The President of the Detroit group, Mr. William Schultz, Jr., invited the members and friends of the Windsor Centre to join in this meeting.

The details of our meetings follows:

January 14,—Otto M. Fisher, M.D.: "The Paricutin Volcano."
February 11,—Prof. O. C. Mohler, Ph.D.: "The Selection of Solar Research Problems." Observer's Handbook address by Cyril Hallam, B.A.
March 11,—Ellis D. Kane, B.S.E.: "The 200 inch Telescope."
April 15,—Prof. E. R. Phelps, Ph.D.: "Spectroscopy as Applied to Astronomy."
May 13,—William Lloyd, Dan Scott, Beverley Carson, Henry Lee and Cyril Hallam: Panel Discussion: "Is There Life on Mars?"
June 10,—Mrs. M. Back and all present: "An Astronomical Quiz." Refreshments served by Mr. and Mrs. D. C. Bawtenheimer.
September 16,—William Schultz, Jr., B.S.E., M.S.Ed.: "Exploring the Universe."
October 21,—H. K. Rowan, B.S.E.: "Grinding, Polishing and Figuring of Telescopic Mirrors."
November 18,—Frederick W. C. Jones, B.Sc.: Films in Colour—"Holland Tulip Festival." Annual Meeting, Reports and Election of Officers. Social Hour and Refreshments.

RUSSELL WARWICK, *Secretary.*

FINANCIAL STATEMENTS, 1947

I. GENERAL TREASURER

GENERAL ACCOUNT

Bank balance December 31st, 1946		$2,135.69
RECEIPTS		
Grants Received—Ontario (1947 Grant)	$ 500.00	
Grants Received—Canada	1,620.00	
Grants Received—Ontario (1948 Grant)	500.00	
75 Subscriptions—University of Toronto	150.00	
Fees	3,005.70	
Subscriptions	125.29	
Publications	1,185.43	
Bond Interest	87.26	
Advertising	90.00	7,263.68
		$9,399.37
DISBURSEMENTS		
Publications	5,119.45	
Grants to Centres	1,013.50	
Stamps and stationery	309.05	
Salary	804.08	
Rent	480.00	
General expense	102.48	
Audit	50.00	
Exchange	49.88	7,928.44
Balance in bank December 31st, 1947		$1,470.93

BUILDING ACCOUNT

Bank balance December 31st, 1946	419.17
Bond Interest	188.26
Balance in bank December 31st, 1947	$607.43

LIFE MEMBERSHIP

RECEIPTS		DISBURSEMENTS	
Bank balance Dec. 31, 1946	$240.48	Safe keeping of bonds	$ 9.15
Life Memberships	125.00	Bank balance Dec. 31, 1947	356.33
	$365.48		$365.48

SOUTHAM PRESS FUND

Cash balance deposited in General Account

Bank balance December 31st, 1946	$162.94
Bond Interest	60.25
Balance in bank December 31st, 1947	$223.19

SUMMARY: BONDS AND DEBENTURES HELD BY R.A.S.C.

Account	Dec. 31, '46	Purchased 1947	Sold 1947	On hand Dec. 31, '47	Yearly interest
Life members	$ 900.00			$ 900.00	$ 27.01
Building fund	6,200.00			6,200.00	188.26
Southam Press	2,050.00			2,050.00	60.25
	$9,150.00			$9,150.00	$275.52

BALANCE SHEET DECEMBER 31, 1947.

Assets

Cash in bank			
Imperial Bank of Canada		$2,434.69	
Invested in bonds			
Life members	$ 900.00		
Building fund	6,200.00		
Southam Press	2,050.00	9,150.00	
Accounts receivable		209.17	
Inventory of publications		751.00	
Prepaid insurance		8.50	
Furniture and fixtures			
Estimated value December 31st, 1944		4,684.00	$17,237.36

Liabilities

Accounts payable		997.75	
Prepaid grant		500.00	
Surplus December 31st, 1945	15,977.88		
Expense in excess of revenue	238.27	15,739.61	$17,237.36

Audited and certified correct:

H. M. Moncrief, *Certified Public Accountant.*

J. H. Horning, *General Treasurer*

II. REPORTS OF TREASURERS OF CENTRES

TORONTO CENTRE

Receipts		Disbursements	
Balance from previous year	$307.28	Rental	$ 56.85
Grant from General Council	243.00	Postage—Stationery	14.35
Fee for Astronomical Services at Toronto Exhibition, 1947	150.00	Expenses re Meetings	33.15
		Printing	10.13
		Catering for General Society	50.00
		Insurance on Equipment	9.00
		Balance carried forward	526.80
	$700.28		$700.28

T. H. Mason, *Treasurer.*

OTTAWA CENTRE

Receipts		Disbursements	
Balance from previous year	$115.07	Fees to General Treasurer	$104.41
Members' (49) fees	104.00	Expenses of Meetings	227.07
Grant from General Council	65.50	Membership in Can. Scientific Film Assoc.	5.03
Contributions	82.00	Miscellaneous	2.00
Bank Interest	.95	Balance carried forward	51.01
Sales of Observer's Handbooks	22.00		
Totals	$389.52		$389.52

S. A. Mott, *Treasurer.*

HAMILTON CENTRE

Receipts		Disbursements	
Balance from previous year	$ 19.89	Rent	$ 22.00
(40) Members' fees	80.00	Fees to General Treasurer	92.00
Grant from General Council	51.00	Postage & Stationery	20.18
Donation	.25	Printing	15.93
Bank Interest	.40	Expenses re Meeting	8.80
Trip to Richmond Hill proceeds	132.75	Chartered Buses	108.70
		Miscellaneous	1.35
		Balance carried forward	15.33
Totals	$284.29		$284.29

George Murchie, *Secretary-Treasurer.*

WINNIPEG CENTRE

Receipts		Disbursements	
Balance from previous year	$ 54.38	Rentals	$ 10.00
(44) Members' fees	88.00	Fees to General Treasurer	88.00
Grant from General Council	27.00	Postage and Stationery	16.38
Bank Interest	1.56	Expenses re Meeting	2.00
		Constitution and by-laws	.50
		Balance carried forward	54.06
Totals	$170.94		$170.94

MONTREAL CENTRE

Receipts			Disbursements	
Balance October 16th, 1946		$121.72	Postage	$ 69.86
Members' fees—1 Life			Stationery	42.73
242 Annual		509.00	Expenses re Meetings	130.50
Bank Interest		3.31	Library	60.46
Grant from General Treasurer		271.00	Advertising	8.00
Donations			Equipment	112.82
Library Fund	$ 41.00		Miscellaneous	7.58
Equipment	50.00		Fees to General Treasurer	509.00
General	221.50	312.50	Balance in Bank, Oct. 15,	276.58
Totals		$1,217.53		$1,217.53

A. R. MacLennan, *Treasurer.*

VICTORIA CENTRE

Receipts		Disbursements	
Balance from previous year	$ 6.76	Rentals	$ 42.00
(128) Members' fees	241.00	Fees to General Treasurer	241.00
Grant from General Council	95.50	Postage and Stationery	22.86
Bank Interest	.40	Expenses re Meeting	20.00
Interest on bond	3.00	Library	10.00
Collection, lecture	58.27	Deficit, Annual dinner 1946	4.30
Profit, Summer Lectures	109.43	Moving costs (telescope and library)	80.50
Donation	10.00	Advertising, florists	10.40
		Balance carried forward	93.30
Totals	$524.36		$524.36

ASSETS

The following is a list of the Centre's assets, with an estimate of the present value of the property:

Dome Building	$ 300.00
One 1941 Victory Bond—par value	50.00
Reid 8-inch telescope and accessories	150.00
Brydon mounting	25.00
Lantern and screen	110.00
Library books and cases	275.00
Wray telescope and accessories	400.00
Mounting for Moore telescope	100.00
	$1,410.00

JEAN K. MCDONALD, *Treasurer.*

LONDON CENTRE

RECEIPTS		DISBURSEMENTS	
Balance from previous year	$ 92.57	Fees to General Treasurer	$ 70.00
(37) Members' fees	74.00	Postage and Stationery	38.80
Grant from General Council	35.00	Expenses re Meeting	11.95
Bank Interest	.54	Balance carried forward	81.36
Totals	$202.11		$202.11

A. EMSLEY, *Treasurer.*

VANCOUVER CENTRE

RECEIPTS		DISBURSEMENTS	
Deficit from 1946	$ 32.24	Fees to General Treasurer	$112.00
Grant from General Council	41.00	Expenses re Meetings	22.50
Bank Interest	.98	Stenographer	11.75
Members' fees	112.00	Stamps, etc	2.15
Overpayment of Fees	.50	Refund of overpayment	.50
		Balance carried forward (deficit)	26.66
Totals	$122.24		$122.24

G. W. OWEN, *Treasurer.*

EDMONTON CENTRE

Receipts		Disbursements	
Balance from previous year	$ 29.45	Janitor	$ 9.53
(30) Members' Fees	60.00	To General Treasurer	1.50
Grant from General Council	47.35	Postage and Stationery	15.43
Bank Interest	.60	Expenses re Meeting	5.55
Handbooks	.50	Guest Tickets	1.70
		To Secretary	11.03
		To Parent Society	60.03
		Balance carried forward	33.13
Totals	$137.90		$137.90

(Miss) A. M. P. Smith, *Treasurer.*

QUEBEC CENTRE

Receipts		Disbursements	
Balance from previous year	$333.54	Fees to General Treasurer	$217.00
(62) Members' fees	134.12	Administration	399.96
Grant from General Council	87.00	Postage and Stationery	37.32
Grants	45.00	Expense re Meeting	30.00
Loan	86.50	Balance carried forward	2.90
Bank Interest	1.02		
Totals	$687.18		$687.18

Paul H. Nadeau, *Secretary-Treasurer.*

WINDSOR CENTRE

Receipts		Disbursements	
Balance from previous year	$32.77	Honorarium to Caretaker	$ 2.00
Members' fees for 1947		Expense of social meeting	1.00
Senior 41, Junior 7	89.00	Fees to General Treasurer	113.00
Grant from General Council	50.00	Subscription, Education Council	2.00
		Membership Cards, General Treasurer	.15
		Complimentary Memberships to Dr. Phelps, Dr. Mohler and Mr. Schultz	8.00
		Postage and other expenses	5.96
		Balance on hand Nov. 18	39.66
Totals	$171.77		$171.77

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

OFFICERS, FOR 1948

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Librarian—C. M. GOOD
Council—A. M. DONNELLY; DR. D. E. DOUGLAS; ROSS FORD; F. W. HENSHAW; A. KNEELAND A. R. MCLENNAN; F. P. MORGAN; W. H. C. MORTON; DR. W. BRUCE ROSS; E. RUSSELL PATERSON; D. P. GILLMOR.

VICTORIA CENTRE

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President—A. MCKELLAR, PHD.
First Vice-Pres.—J. S. STEVENSON, PH.D.
Second Vice-Pres.—MRS. J. R. NOBLE
Secretary-Treasurer—MISS J. K. MCDONALD, Dominion Astrophysical Observatory
Recorder—G. L. DARIMONT
Director of Telescopes—ROBERT PETERS
Librarian—MISS Y. LANGWORTHY
Council—R. S. EVANS; JOHN JERVIS; E. H. POPE; H. A. REID; M. TRUEMAN; MRS. C. S. YARWOOD.

LONDON CENTRE

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Vice-President.—O. Kilburn *Past-Pres.*—DR. R. H. COLE
Secretary-Treasurer—A. EMSLEY, 831 Richmond St.
Council—E. E. O'CONNOR; M.O. CULBERT; J. W. BRYCE; MRS. A. DAVIES; J. C. HIGGINS.

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Vice-President—P. J. SYKES *Recording-Secretary*—C. W. DEANS
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OUT OF OLD BOOKS

By Helen Sawyer Hogg

Sabine's Correlation of Sun-spots with Magnetic Disturbances

In the last number of this Journal we reprinted Schwabe's discovery of the sun-spot cycle, and commented that Schwabe himself was the first person to attempt to correlate the spot cycle with temperature and barometer readings. Immediately upon the publication of his work in 1851, two men, Lamont in Germany and Sabine in England, who were working independently on magnetic observations, found that periodic terms in them were strongly correlated with the sun-spot cycle.

Of particular interest to the Canadian readers of this Journal is the fact that a long series of observations made at Her Majesty's Magnetical Observatory at Toronto over some years, beginning in 1840, was used by Col. Sabine to show that there was a strong correlation between the disturbance of the magnetic declination, and the number of solar spots. Sabine used thousands of observations, taken hourly at Toronto and at Hobarton on Van Diemen Island, now Hobart, Tasmania, which involved an enormous labour both in the taking and the reducing. He published in the *Philosophical Transactions of the Royal Society* a series of three lengthy papers, entitled *On Periodical Laws discoverable in the mean effects of the larger Magnetic Disturbances.* The first was published in 1851 before Schwabe's work had become common knowledge. The second paper was published in 1852, shortly after the appearance of the Cosmos, and correlates the magnetic disturbances with Schwabe's assiduous spot records. The third paper was published in 1856 when the observations from Toronto were entirely finished and reduced, and in this Sabine pays special compliment to the diligence of the work at Toronto.

In his paper in 1851, Col. Sabine gave the summary of the magnetic disturbances of the years 1843, 1844, and 1845 as observed at Toronto and Hobarton. In the paper of 1852 he adds the

observations from the years 1846, 1847, and 1848, and in a postscript, those of 1841 and 1842. And he is impressed with the correlation of the magnetic disturbances with the recently published sun-spot cycle of Schwabe. He says (*Phil. Trans.* vol. 142, p. 103, 1852):

I have had the satisfaction of finding that the observations of these years confirm every deduction which I had ventured to make from the analysis of the disturbances of the former period; whilst new and important features have presented themselves in the comparison of the frequency and amount of the disturbances in *different years*, apparently indicating the existence of a *periodical variation* which, either from a causal connection (meaning thereby their being possibly joint effects of a common cause), or by a singular coincidence, corresponds precisely both in period and epoch, with the variation in the frequency and magnitude of the solar spots, recently announced by M. SCHWABE as the result of his systematic and long-continued observations.

Sabine discusses the averages of the magnetic disturbances in three ways, 1, diurnal, through different hours of the day and night; 2, monthly, by different months of the year, and 3, in different years. He points out that Lamont has studied the mean monthly range of Declination and shown a periodic tendency in its fluctuations over some years, (op. cit. p. 118).

In a recent number of POGGENDORFF'S Annalen, 1851, No. 12, December 23 (which only reached the author of this paper when the greater part of it was already written), Dr. Lamont has published a Table of the mean monthly range of the diurnal variation of the Declination at Munich, from 1841 to 1850 inclusive, from which he also has been led to infer the probable existence of a periodical inequality, having its epoch of minimum in 1843.5, and of maximum in 1848.5, - - - Dr. Lamont confines himself entirely to the diurnal inequality of the Declination, leaving untouched the subject of the disturbances (or, as they are more usually termed in Germany, the magnetic storms).

Sabine collected the disturbed observations from the Toronto and Hobarton work. Since the observations were made hourly,

. . . . every hourly observation which was found to differ by a certain prescribed amount from the mean value of the Declination in the same month and at the same hour was separated from the rest, and a body of *disturbed observations* was thus collected, of which the recognised characteristic was simply that they were the disturbances of largest amounts occurring in the whole period. - - - The *mean* hourly, monthly, and yearly numbers and aggregate values in the whole period were then taken as the respective units, and the ratios to these units computed for each of the hours, months, and years. - -

Table XIII exhibits the ratios of the numbers and aggregate values of the disturbed observations at Toronto and Hobarton in the different years, to the average annual number and aggregate value respectively.

TABLE XIII

Years	Numbers		Values	
	Toronto	Hobarton	Toronto	Hobarton
1843	0.68	0.52	0.55	0.48
1844	0.76	0.81	0.73	0.82
1845	0.72	0.72	0.62	0.67
1846	1.31	1.09	1.26	1.03
1847	1.19	1.36	1.40	1.44
1848	1.37	1.50	1.43	1.60

--- the facts which present themselves most obviously and unquestionably to our notice are, that in the years 1843, 1844 and 1845, the ratios were uniformly *considerably less than unity*, and that in the years 1846, 1847 and 1848, they were as uniformly *considerably greater than unity*. -- The ratios of disturbance in the years 1846, 1847 and 1848, were nearly *twice as great* as in the years 1843, 1844 and 1845. ---

The variation in the amount of disturbance in the different years presented in this Table, has certainly far more the aspect of a *periodical inequality*, than of what may be called for distinction's sake, *accidental* variation. --- But the existence of a periodical inequality of this nature, affecting at the same time, and in the same manner, parts of the globe most remote from each other, would be a circumstance of such extreme importance in theoretical respects, that we are bound to receive the facts which may appear to indicate it with the utmost caution, and to await the confirmation it may obtain from contemporaneous observations at other stations. ---

In our present ignorance of the physical agency by which the periodical magnetic variations are produced, the possibility of the discovery of some cosmical connection which may throw light on a subject as yet so obscure, should not be altogether overlooked. As the sun must be recognized as at least the *primary* source of all magnetic variations which conform to a law of local hours, it seems not unreasonable that in the case of other variations also, whether of irregular occurrence or of longer period, we should look in the first instance to any periodical variation by which we may learn that the sun is affected, to to see whether any coincidence of period or epoch is traceable. Now the facts of the *solar spots*, as they have been recently made known to us by the assiduous and systematic labours of SCHWABE, present us with phenomena which appear to indicate the existence of some periodical affection of an outer envelope, (the photosphere,) of the sun; and it is certainly a most striking coincidence, that the period, and the epochs of minima and maxima, which M. SCHWABE has assigned to the variation of the solar spots, are absolutely identical with those which have been here assigned to the magnetic variations. In the third volume of Kosmos, -- Baron von HUMBOLDT has published a tabular abstract supplied by M. SCHWABE.- - - -

M. SCHWABE has not been able to derive from the indications of the thermometer or barometer any sensible connection between climatic conditions and the number of spots. The same remark would of course hold good in respect to the connection of climatic conditions with the magnetic inequalities, as their periodical variation in different years corresponds with that of the solar spots. But it is quite conceivable that affections of the gaseous envelope of the sun, or causes occasioning those affections, may give rise to sensible *magnetical* effects at the surface of our planet, without producing sensible *thermic* effects.

As the physical agency by which the phenomena are produced is in both cases unknown to us, our only resources for distinguishing between accidental coincidence and causal connection seems to be *perseverance in observation.* - - - For such continued investigation we must look to those observatories which are permanent in their institution; and in this particular problem, to those especially which combine astronomical and magnetical research. The hourly observations at the British Colonial Observatories, which, combined with M. SCHWABE'S observations of the sun in Germany, have led to the discovery of the existence of the coincidence during the years 1843-1848, ceased in 1848, having accomplished the special objects for which they were instituted. - -

Woolwich, March 16, 1852.

And in his third paper, (*Phil. Trans.* vol. 146, p. 357, 1856,) Col. Sabine sums up the problems, and pays a special tribute to the diligence with which the observations were made at Toronto, as follows:

The interest and the importance of the inquiry have doubtless been greatly enhanced by the remarkable coincidence, which it was the object of the paper communicated to the Royal Society in March 1852 to announce, between the above-described periodical inequality by which the magnetic variations referable to solar influence are affected, and the periodical inequality which has been discovered by M. SCHWABE to exist in the frequency and magnitude of the solar spots. The coincidence, as far as we are yet able to discover, is absolute; the duration of the period is the same, and the epochs of maximum and minimum fall in both cases in the same years. - - As a discovery which promises to raise terrestrial magnetism to the dignity of a cosmical science, we may feel confident, that, although the Colonial Observatories have been brought to a close, the investigations which they have thus successfully commenced will be pursued to their proper accomplishment, in those national establishments which have a permanency suitable for such undertakings. - - -

May it not be hoped, that the fruits which have recompensed the labour bestowed on the Toronto observations, may encourage some amongst the numerous physicists in Europe and America, who signified their desire to cooperate with the Royal Society in this inquiry, and to adopt the methods and processes of observation which have been followed out at Toronto, to apply themselves to the deduction of the laws of the occasional disturbances which, from the example of Toronto, they may expect to be able to disentangle from the great

mass of observations on which their labour has been already bestowed; provided that those observations have been made with the care and perseverance which have distinguished those made by the Officers and Non-commissioned Officers of the Royal Artillery at the Toronto Observatory? Few may be willing to face a heavy labour of reduction before experience has shown that results will follow from the labour; but some may be expected to do so when an example is before them that this additional labour bestowed on their observations will not be without its recompense: a very few stations at which the investigation should be as full and as satisfactory as at Toronto, might, if widely distant from each other on the earth's surface, suffice to form a general theory of the phenomena of the magnetic disturbances. - - -

Woolwich, February 1, 1856.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Wirtanen's Asteroid

Mr. C. A. Wirtanen, of the Lick Observatory, has found a very interesting asteroid, which approaches fairly close to the earth. Dr. Cunningham, of the University of California has supplied the following preliminary elements, (Harvard Announcement Cards 895, 896 and 898):

Perihelion passage,	T = 1948 May 21.55982 U.T.
Perihelion distance,	q = 0.89387
Eccentricity,	e = 0.61115
Long. of perihelion,	ω = 264°.676
Long. of ascending node,	Ω = 348°.937
Inclination of orbit plane,	i = 18°.652

The brightness this spring will range between the 12th and 16th magnitudes, and at its closest approach its distance will never be less than about 15 million miles. This is about the same as a close approach of Eros, but it is from eight to twenty times as great as that of Apollo, Adonis or Hermes.

F. S. H.

Astronomy in the Magazines

It is encouraging when magazines of general interest and wide circulation devote considerable space to astronomical events,—albeit the occasion at present is the completion of the greatest telescope ever attempted. Life, in its December 8, 1947 issue, carried photographs of the journey of the 200-inch disc to its final resting-place on Mount Palomar. A short, but significant article on the fabulous new field of radiowave astronomy, with a photograph of Reber and his radio telescope, is to be found in Time, January 5, 1948.

Time of February 9, has as its cover a striking photograph of the well-known astronomer Dr. Edwin Hubble, with a hand pointing "ad astra", and carries an article of some pages on his work on nebulae, and the aspirations for the new realm of the 200-inch. A diagram of the volume of space which can be explored with various instruments is

vivid and well done. Astronomically minded persons will derive sardonic amusement at Time's remark of the relative respect in which astronomy and astrology are held: "A studio, planning a movie about the stars, hired a Mount Wilson astronomer as consultant. He was happy with his easy $200 a month until he discovered that the studio had also hired an astrologer—at $1,500."

With the great publicity value of the 200-inch telescope, and more astronomical information imparted by periodicals of wide circulation, the true worth of astronomy versus astrology may be brought home to millions who now cannot differentiate between them.

H. S. H.

A New Satellite To Uranus

A fifth satellite to Uranus has been discovered at the McDonald Observatory of the University of Texas, announced by Dr. G. Kuiper on March 9 (Harvard Announcement Card 980). It was first photographed with the 82-inch telescope on February 15, and was confirmed on two plates taken on March 1. The four previously known satellites, in order of distance from the planet, are Ariel, Umbriel, Titania and Oberon. The two outer satellites were discovered by Wm. Herschel in 1787; they are very faint and are perhaps a thousand miles in diameter. The two inner satellites were discovered by Lassell in 1851 and are smaller and still fainter than the others. The new satellite is closer to the planet than Ariel, being only nine seconds of arc from Uranus. It is of 17th magnitude, even fainter than Ariel and Umbriel. The period of revolution has not yet been announced, but it may be expected to be about 30 hours.

Details of the orbits of the four outer satellites are given in the *Observer's Handbook* for 1948, page 59. It might be mentioned that at the present time the plane of the orbits is very nearly at right angles to the line of sight, so the satellites appear to move in almost circular paths. Not until about 1966 will the orbits be again seen edge-on.

R. J. N.

MEETINGS OF THE SOCIETY

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CLARK, E. K.....Fairview Ave., Nanuet, N.Y..
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DAVIS, M.S.....Yale University Observatory, New Haven 11, Conn.
DE REUCK, A. V. S.....111, Onslow Gardens, Wallington, Surrey, England.
FOLKMAN, G. E.....43½ S. Gratiot, Mount Clemens, Mich.
GODLEY, H.....Mullynure, Armagh, N. Ireland.
GOETZINGER, MISS V. K. .816 South 9th St., La Crosse, Wisc.
HARWOOD, MISS M.....Maria Mitchell Observatory, Nantucket, Mass.
JENSEN, A.....2320 Creston Ave., Bronx, N.Y.
KRASBERG, A.....808 Raleigh Road, Glenview, Ill.
LAZARO, S.....1964 N. Orchard St., Chicago, Ill.
LOAN, R. W.....1916 Calvert St. N.W., Washington 9, D.C.
MASON, F. G.....53 Atlantic St., Halifax, N.S.
MCARTNEY, J. H.....18 Dupont, St. Ave., Buffalo, N.Y.
MIDDLETON, R. S.....44 George St., Brantford, Ont.
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NICHOL, F. T.....District Engineer, Dept. of Highways, Sudbury, Ont.
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RIEGER, T. F.....Mirror, Alta.
SKIRVING, S. L.....213 Glenwood Ave., Cincinnati 17, Ohio.
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STYRAN, PETER.....R.R. 1, Shartdale, Man.
TATUM, W. L.....214 No. 32nd St., Richmond 23, Va.
TOMER, E.....319 Cypress St., Alameda, Cal.
VICKERY, E. R.....532 Cresent Road, Calagry, Alta.
WELLS, P. H.....155 Washington Ave., Chatham, N.J.
WONNACOTT, E.....84 Upper Prince St., Charlottetown, P.E.I.

AT SASKATOON

October 6, 1947. The first meeting of the Saskatoon Centre of the Royal Astronomical Society of Canada was held on October 6th in the Physics Building at the University. The speaker was Professor Katz of the Physics Department, and his subject, "The Two Hundred Inch Telescope."

The speaker briefly outlined the main types of telescope mountings, and discussed their advantages and disadvantages. The 200-inch telescope will be used several ways optically, depending upon the type of problem being investigated. The speaker mentioned the problem of supporting the great weight of the telescope. The conventional type of bearing did not prove satisfactory, and it was finally decided to support the structure on a thin oil film under high pressure. Dr. Katz told of the casting of the mirror, and explained the various stages of grinding and polishing the surface. He showed a number of slides of

the construction of the mechanical parts of the telescope, and indicated certain engineering problems which had to be solved. The speaker concluded with a few remarks about the main problems which will be investigated with the 200-inch telescope, and suggested that exciting announcements will soon be made after the telescope is put into operation.

The audience spent some time observing the double clusters in Perseus with the six-inch refractor of the University.

October 20, 1947. The speakers at this meeting were Mr. W. Mitchell and Mr. W. Buscombe. Mr. Mitchell's subject was, "The Making of a Reflecting Telescope." The speaker discussed the various types of curved surfaces that might be used as telescopic mirrors, and explained the advantages and disadvantages of the various types. A parabolic surface is used because of its useful focussing properties. The speaker went on to explain how a parabolic glass surface is secured. The basic grinding procedure gives the glass a spherical surface, and the parabolizing is accomplished by final polishing with rouge. Mr. Mitchell discussed the knife-edge shadow test which enables one to test surfaces to a remarkable degree of accuracy.

Mr. Buscombe gave an interesting talk on the larger telescopes which are in use today. He showed slides of different types of telescopes and mountings, and concluded with an explanation of the performance of the Schmidt telescope.

November 19, 1947. The speaker at this meeting was Dr. J. B. Mawdsley, head of the Department of Geology at the University of Saskatchewan. Dr. Mawdsley delivered a very interesting lecture on "Major Features of the Earth's Crust." The speaker pointed out that the earth has a very elastic composition, at least as elastic as steel. If the earth were dropped on a hard surface, it would bounce very easily.

The specific gravity of the earth is 5.5, and since the crust consists of relatively light elements, the centre of the earth must contain a high percentage of heavy elements, possibly nickel and iron. Dr. Mawdsley briefly discussed the mountain building and erosion processes that have been acting for a long period of time. He traced the history of certain regions of the North American Continent.

December 15, 1947. The speaker at this meeting was Mr. W. Buscombe of the Mathematics Department at the University. His topic was, "Modern Methods in Weather Forecasting." The speaker outlined a number of the historical developments which have contributed to modern meteorology. The subject could be treated quantitatively once instruments were produced which measure pressure, temperature, and humidity. The first weather maps were drawn in 1820 by a German mathematical astronomer named Brandes. The technique of forecasting was instituted in 1913 by Bjerknes. The speaker went on to explain modern methods of measuring physical conditions in the upper atmosphere by means of the radiosonde. This useful device records temperature, pressure, and humidity, and broadcasts the information to the earth. Mr. Buscombe explained cloud classification and showed photographs of the various cloud types. He showed a series of weather maps drawn on successive days, and explained how forecasting may be carried out by observations of the positions and motions of fronts.

W. PETRIE, *Recording Secretary*

AT VANCOUVER

November 18, 1947—There was a very interesting evening of motion pictures on astronomy and allied subjects. Lt. Comm. McDonald announced the new slate of officers and the past president Norman Barton was thanked for his work of the past year.

December 9, 1947—Dr. G. G. Eicholz, of the Department of Physics of the University of B.C. gave a very interesting lecture "The Measurement and Detection of Cosmic Rays." Various methods of detecting these elusive rays were shown such as the ionization chamber, the Wilson expansion chamber, the Geiger counter and the direct photography method on a sensitive film. Dr. Eicholz showed many slides of paths of particles of various kinds including the meson-mesotron paths. Shower effects were demonstrated. Dr. Eicholz told the listeners that about one particle per minute was passing from outer space through every cubic centimetre at earth's surface. He emphasized the need for further research.

January 13, 1948—Dr. K. R. More, Department of Physics, U.B.C. gave an interesting lecture on "The Search for Oil." Dr. More emphasized that oil was a wasting asset and was running out so that much money was being spent in exploration various ways. Drilling for a well, being about $250,000 for a 15,000 ft. well, is often too expensive. Other methods of preliminary exploration are used. These are the methods which search for sub-surface distortions indicating oil reservoir structures. These are divided into (1) gravitational using the Torsion balance, pendulum or gravimeter. (2) Magnetic using the magnetometer to detect field distortions due to subsurface oil formations. Air-borne magnetometers have been used over the oceans also. (3) Seismic with artificially created earth shocks and seismic recording apparatus capable of picking up even the microseisms of the winds. Seismic surveys are often quite accurate, but the cost about $7,000 to $15,000 per month! It is usual to use the gravimetric and magnetic method for preliminary surveys and then go into a likely field with the seismic field party. About 90 per cent. of all moneys spent on surveys are used in the seismic method. Dr. More's address was well received and questions were answered.

February 3, 1948—Dr. J. A. Pearce, Director of the Dominion Astrophysical Observatory at Victoria, gave a most instructive lecture "The O-Type Stars." Dr. Pearce explained the position of the O-type stars in the Russell Diagram. The O-type stars have been studied as a special research project by the Dominion Astrophysical Observatory. Dr. Pearce pointed out that of the 117 good reports over 91 per cent. had been made in Victoria. These O stars are the hottest and rarest, the most massive and luminous. Their masses are about 35-40 times the sun's mass. They seem to occur within plus or minus one degree from the galactic plane. Dr. Pearce had many original charts appearing for the first time to illustrate his most interesting address. Dr. Crooker gave the vote of thanks.

March 9, 1948—Miss J. K. Macdonald, Secretary of the Victoria Centre came on 24 hours notice and delivered a most interesting illustrated lecture who had influenza. He was to have lectured on "Stellar Motion—Some on "The 200-inch Palomar Telescope." She took the place of Dr. R. M.Petrie Problems." Miss Macdonald had had the good fortune of being on the site when the giant mirror was finishing grinding and being placed in the gigantic framework at Palomar. She gave the whole history of the $6,550,000 project. The mirror accurate to one tenth of the wave-length of green light. With a new spectroscope giving 16 feet spread from red to violet the astronomers expect to learn much more about the stellar universe. Hydrogen variation, origin of the elements, history of the universe, expansion or non-expansion of the universe, canals on Mars and phenomena on other planets are some of the subjects for research. Miss Macdonald's ability to give such a wonderful lecture on such short notice indicates the high calibre of the members of the Victoria Centre.

C. W. DEANS, *Secretary*

AT WINNIPEG

December 10, 1947—The Annual meeting of the Winnipeg Centre was held on December 10th in Theatre "B" of the University of Manitoba. Mr. L. W. Koser presented the last in the series of "Astronomy in the News." He told of the recent discovery of the existance of carbon dioxide in the atmosphere of Mars, which strengthens the case ofr life on that planet.

Mr. H. E. Rasmussen demonstrated an electronic strobotron which he has made, showing some very interesting experiments to demonstrate its use in industry.

Mr. D. R. P. Coates gave the presidential address. His subject was "Sun-spots." His lecture traced the study of sun-spots from the beginning of the 17th century to the present time. The sun's rotation was ascertained by sun-spots to be 24 days 7 hours at the equator and about 30 days near the poles. The spectroheliograph showed that sun-spots resembled cyclones. They have magnetic fields of opposite polarity to sun-spots the other side of the sun's equator. As the sun-spot period progresses they move nearer to the equator. They appear in pairs parallel to the equator. The vortex directions of pairs are opposite and the magnetic polarity is opposite. In 1925 Hale and Nicolson established the reversal of polarity in the preceding sun-spot of a pair as a new cycle is begun; which means the magnetic cycle is double the sun-spot cycle, which amounts to about a 23 year period. Professor Hall Turner of Oxford University advocates the recognition of this 23 year period instead of the popular 11½ year cycle. The speaker traced the effects of sun-spots on communications here on earth and of the investigations now being carried on by the use of radar.

The annual business meeting was held following the address and the election of officers for 1948 was held following the secretary's and treasurer's reports.

CHARLES G. CARD, *Secretary*

A QUEBEC

Le 21 février 1948—Cette réunion, tenue à l'amphithéâtre de Physique de l'université Laval, était sous la présidence de monsieur J.-Lucien Pouliot.

Le sujet de la causerie faite par monsieur Albéric Boivin, professeur à la Faculté des Sciences de l'université Laval, avait pour titre: "Les fusées et la possibilité du vol interplanétaire."

M. Boivin a d'abord donné quelques notes historiques sur les fusées, dont l'étude sur une base scientifique remonte aux premières années du présent siècle. Puis il a décrit la fusée V-2, le prototype des engins réalisés durant la guerre et perfectionnés à la suite des recherches récentes.

Actuellement, on réussit à expédier des V-2 à une altitude si grande dans l'atmosphère que la pression de l'air y est presque nulle. Bientôt, dans quelques années, révèle M. Boivin, on leur fera atteindre une hauteur telle que l'attraction de la Terre sera inférieure à celle de la Lune.

Le problème du vol interplanétaire préoccupe actuellement un grand nombre de savants et parmi les plus autorisés. Le conférencier a captivé son auditoire nombreux en révélant les solutions d'une ingéniosité extrême qui ont été proposées par les spécialistes en vue de réaliser le vol d'une planète à l'autre. Par exemple, l'idée d'une fusée satellite de la Terre, comme la Lune, qui servirait de base pour les expéditions et de magasin pour le combustible.

Actuellement, le grave problème de la navigation interplanétaire—pour les terriens que nous sommes—est de trouver une source d'énergie suffisante pour permettre à l'astronef de sortir de l'attraction terrestre. L'obstacle n'est pas dans le vide interplanétaire ou les conditions physiologiques nouvelles, créées par le déplacement rapide du véhicule. L'utilisation de l'énergie atomique comme agent propulseur simplifiera grandement le travail des chercheurs.

Le conférencier a été présenté par M. Chs.-A. Giroux et remercié par le Président. M. Léon D. Descarreaux a dit quelques mots à la fin de la séance, au nom du Comité Publicitaire dont il est le directeur.

PAUL-H. NADEAU, *Le secrétaire*

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